An Evaluation Design to Assess Participant Satisfaction With The Project Lead The Way Teacher Training Program

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INTRODUCTION

American policy makers engaged with K-12 education have stated the need for improved student performance in the disciplines of Science and Mathematics since the early 1980's (Breiner et. al. 2012). Dozens of committees have been tasked with tackling this issue and many research studies conducted with suggestions for improving the nations education system. For example, in the 1983 publication *A Nation At Risk* the National Commission on Excellence in Education proclaimed that generation of secondary students to be scientifically and technologically illiterate (NCEE, 1983). The NCEE believed the quality and rigor of secondary education in the U.S. to be insufficient, diluted and incapable of serving its fundamental purpose of preparing students to succeed and compete in the global economy. Recommendations put forth included an increased focus on math and science in our schools and raising the math and science standards for high school graduation.

Fast forward 24 years and the Committee on Prospering in the Global Economy of the 21st Century made similar recommendations, echoing the need for improved K-12 education in their publication *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (2007).* The committee's proposals embrace training additional teachers in the STEM fields and promoting a general focus on improving and investing in STEM education at the secondary school level. They argue that American advantages in labor and capital will not sustain the United States as the dominant global economic force. Teaching research and development skills combined with the ability to independently acquire and apply

knowledge creatively are the keys to successfully competing in the global economy over the next few decades (p. 46). By improving K-12 STEM education, the committee argues, our students will develop these skills at a younger age and will be better prepared for their higher education careers.

This increased focus on STEM education correlates with a burgeoning demand for properly trained scientists and engineers in a growing number of technologically based jobs across all sectors of the economy. A 2011 report by the U.S. Department of Commerce's Economics and Statistics Administration (ESA) reported that in 2010, approximately 5.5% of all jobs in the US were STEM related. While a relatively small portion of total employment, jobs in this sector are projected to grow 17% between 2008 -2018, nearly twice as high as non-STEM jobs. More than two thirds of STEM workers hold at-least a Bachelor's degree and earn, on average, 26% more than workers in other sectors of the economy. STEM workers experience joblessness at a lower rate than non-STEM workers and usually fare better than their non-STEM counterparts when they do (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Langdon et. al. go on to argue that STEM has an outsized impact on the economy and will be the main driver of America's ingenuity, creativity and key technological and economic advancements in the future.

In addition to these developments, the hugely popular 2005 publication by Thomas Friedman *The World is Flat,* put a spotlight on advancements made by both India and China purportedly at the expense of the United States. Friedman specifically references the need to improve our approach STEM and how we educate the next generation. He argues that we must ensure students have technological literacy to maintain our technological and economic advantages into

the future. The critical result was that technology and engineering are now seen as equally important to science and mathematics allowing for a serious push for the integrative approach he and others are advocating for (Sanders 2009).

There have since been many initiatives and programs aimed at improving K-12 education including *The STEM Education Coordination Act of 2009* established by The Office of Science and Technology Policy (Congress House Report, 12/6/2016). This new entity is tasked with overseeing and funding relevant STEM initiatives such as *100K in 10*, *Educate to Innovate* and *Change the Equation* (White House Administration, 12/2/2016). Other initiatives included *Race to the Top,* which funded nearly $4 billion in grants to state level education initiatives as part of the 2009 American Recovery and Reinvestment Act. STEM based initiatives were prioritized and the final grants were completed in 2015 (DOE, 2015).

The stakes are high. American students must have access to an education that imparts technological literacy. This is crucial to the future success of the American economy and for efforts aiming to decrease the education and wage gaps that persist in our society. Through this paper the author will propose an action evaluation design of a teacher training program offered by a non-profit K-12 STEM education organization, Project Lead The Way. As stated on their website, PLTW provides transformative, hands on learning experiences that empower K-12 students to develop in-demand knowledge and skills (PLTW, Our Programs and Curriculum n.d.). The main instrument used to deliver the curriculum are current K-12 teachers who are trained through a specialized Train the Trainer approach. The Core Training Institute, or CTI,

aims to train teachers and provide resources to engage students through real-world learning and the primary focus of this evaluation.

LITERATURE REVIEW

A review of the relevant literature reveals several key topics to be explored and defined. In-order to proceed we must define what we mean by STEM, what constitutes the most effective way to teach STEM in K-12 schools and what the current state of research on the subject tells us. We must also examine the effectiveness of the train the teacher model currently employed by PLTW and we must explore and define what an action evaluation model is and why it should be used in this context.

Definition of STEM

STEM education and the jobs and industries it feeds will remain a critical part of the United States economy both now and into the foreseeable future. STEM also offers an important pathway to personal success for students and professionals who develop the skill set required to excel in these fields. But what is STEM exactly and how is it defined? In an article titled *STEM, STEM education, STEM mania,* Sanders (2009) discusses how the term was first used by the National Science Foundation in the 1990's in-reference-to four disciplines; Science, Technology, Engineering and Math. The original term SMET was thought to be off-putting resulting in the terminology used today.

Increasingly, STEM is thought of as an integrated curriculum combining all related disciplines into one comprehensive and dynamic subject. Both Sanders (2009) and Labov, Reid, & Yamamoto (2010) argue that creating an integrative approach to STEM education is necessary and the most effective way to produce students who possess technological competence. Traditionally, the various STEM disciplines have existed as stand-alone subjects, compartmentalized from each other in our K-12 education system. Sanders (2009) argues that:

> 'technological literacy' delivered through integrative STEM education offer enormous potential for all students throughout K-12 education. In addition to addressing the "technological literacy for all" challenge, it has the potential to motivate young learners with-regard to the STEM subjects as never-before and the potential to maintain their interest in STEM subjects throughout the middle and high school years. If so, integrative STEM education would add enormously to American education, culture, and global competitiveness. Technology education has a key role to play in integrative STEM education, and could play a significant role in twenty-first century American education if it can demonstrate relevance in this way (p. 25)

What is or is not STEM education and how it is marketed, is arguably as important as the policies and ideas themselves. As we have seen in past debates, how a topic is defined and framed to the general-public can often determine the success or failure of the policies put forth. If the average voter can-not easily understand the value of a given initiative, they are not likely to care. Angier (2010) discusses in a New York Times article titled

STEM Education Has Little To Do With Flowers, the negative ramifications of failing to sufficiently brand and explain the drive to normalize and promote STEM as an education construct. Ms. Angier quotes a survey of 5,000 participants in which 86% said they did not understand the term "STEM Education". According to the Entertainment Industries Council, the group who conducted the survey, participants thought of stem cells, broccoli and other plant related imagery rather than a Science and Math based education initiative. There appears to be a lack of understanding outside of the education and industry elites whose research and business interests directly connect with STEM (Angier, 2010).

Breiner et. al. reveal a similar problem with defining STEM amongst the faculty at a large public University (Breiner et. al 2012). Even among research and teaching professionals at The University of Cincinnati, there was no consensus on the definition or conception of what STEM is, even with those involved with research or subjects directly linked to the individual disciplines that make up STEM. As with the general-public, faculty members at UC tend to see STEM as its individual components rather than an integrated disciplinary approach. The study revealed that individuals tend to view STEM through the lens of their own research focus and area of expertise rather than the holistic approach the proponents of STEM hope to promote. Clearly, if we are to fund and promote the idea of STEM as an integrative approach to teaching and learning, we must concurrently educate the public on its significance and importance.

Effective K-12 STEM Education

Given the difficulty in defining the concept of STEM and informing the public and education professionals, it should be no surprise that a clear definition or consensus on the most effective way to advance collaborative STEM education in America's K-12 school system does not currently exist (Hoachlander and Yanofsky 2011). The authors write that in many schools, STEM is only Science and Math with little to no collaboration with technology and engineering. Furthermore, they say that when collaboration is initiated it happens in a disjointed manner, lacking a clear direction with no big picture planning.

Hoachlander and Yanofsky do cite several examples from their analysis of California schools where collaboration has been successful. "Linked learning concepts" (p.62) introduced in several schools is an example to be followed and has been shown to successfully produce a hands on, integrated curriculum through programs such as Project Lead The Way. By producing dedicated pathways for multi-disciplinary collaboration, they argue, students become more engaged and develop technological competencies early in their academic careers.

Asunda and Mativo (2016) suggest the most effective way to integrate a STEM curriculum is for teachers to engage in collaborative teaching. This involves all STEM teachers working together to develop a common curriculum that meets the standards set forth by outside entities such as The Common Core State Standards and Next Generation Science Standards. Asunda and Mativo suggest one pathway for a successfully integrated STEM curriculum that relies on teacher and administrator buy-in and ownership of developing the lesson plans, projects and concepts to be

implemented. They take a theoretical approach to provide a framework for developing the lessons and curriculum appropriate for each individual school.

While identifying a collaborative approach as the optimal way to teach STEM is an important step, the content and theoretical underpinnings of the curriculum itself are just as important. Bybee (2010) advocates a "Curricular Theory of Action (p.33)" for engaging students in a collaborative STEM school environment. Using this method, students are taught through small model instructional units to introduce the discipline specific content are presented with a challenge to solve. This challenge should be something relevant and taken from the local environment. In short, students should care about what they are learning. Because the units are to be small, dynamic and easily integrated into existing curriculum they are relatively easy to produce and deliver. Although Bybee's approach is theoretical, it offers a cost effective and achievable solution for schools who are in the early stages of adopting an integrative STEM approach, or have limited resources, as it does not require significant investments of money or time.

Becker and Park (2011) provide evidence that an integrated approach to STEM in K-16 education has a measurable positive impact on student performance in STEM related coursework. Their meta-analysis of various integrative approaches to STEM education showed a very high impact on student performance when all 4 subject areas are integrated (p. 29). The authors also conclude that early exposure to integrated STEM education can translate to increased success in those disciplines and result in positive attitudes towards STEM fields of study. This contributes to higher rates of success and interest in the STEM fields later in the

students' academic and professional careers. Strong circumstantial evidence suggests early exposure to integrated STEM directly correlates to higher performance, suggesting the value of promoting an integrated approach in the lower grades especially (p. 31).

Becker and Park (2011) acknowledge that significant barriers exist to implementation, including administration support and teacher buy-in, but their analysis is promising and the positive affect of an integrated STEM curriculum seems to warrant further study. The authors stress that while their findings are extremely exciting, the conclusions and results will need to be reproduced in a variety of locations before we can definitively link enhanced student performance to collaborative STEM (p. 32).

Train the Trainer Model Analysis

Based on literature written on effective of K-12 STEM education, it is logical to conclude that an integrative curricular approach is optimal, best delivered through collaborative teaching. Pairing an integrated approach with hands on, relevant projects appears to be an effective way to engage students, increase their interest in the relevant disciplines and to impart the relevant skills needed for future success in a technical field. A significant barrier to implementing this collaborative and integrative STEM curriculum is teacher training. Even if a school, or even individual teachers, are willing to embrace this way of educating students a knowledge gap exists as it pertains to training. Simply put, how do teachers know how to teach this way? One program that incorporates all aspects of integrative and hands on STEM education is Project Lead The Way. This non-profit education organization deals with the training issue through a coordinated

program utilizing a train the trainer (TTT) model to give leadership skills and the technical knowledge to teachers implementing PLTW into their schools.

A train the trainer model uses an expert in the given subject, program, or philosophy to teach and train non-experts to both deliver the material and train others to deliver the material. In this way, the cost of training is reduced and allows for the technical knowledge to travel farther (Herschell, et. al. 2009). A teacher trained through this type of professional development program can train additional instructors in the subject, allowing for easier and more efficient collaboration.

Corelli et. al. (2007) describe one drawback to this training model. The possibility exists for a "watering-down" of the content or an outright inability to transfer the relevant knowledge. While the primary source of training can be regulated, controlled and monitored by the sponsoring organization no such quality controls exist at the school level. Greif et. al. (2015) describe their experiences with a TTT approach to disseminating a treatment program for eating disorders. Their conclusions, while limited by the size and scope of their study, did find the TTT model to be an effective way to transfer and spread their program to select hospitals and clinics. The net effect for all groups involved was positive and is worthy of further study as it relates to a STEM program.

An important factor for the success of a train the trainer program is the ability, or at-least the perceived ability, of participants to successfully teach the program. Do teachers feel they can successfully teach STEM in this way and can they lead an integrated curriculum because of the TTT method? A 2007 evaluation of a TTT program for tobacco cessation yielded promising results as it concluded that participants perceived ability to deliver the program rose significantly

because of a TTT program (Corelli et. al 2007). The authors conclude that a TTT model can be effective for imparting the relevant knowledge and for promoting the adoption of a nation-wide curriculum.

While a significant portion of the literature focuses on clinical or medical programs, the findings are promising and applicable to a STEM based curriculum such as Project Lead The Way. One relevant application was the mostly successful implementation of a social work program in Kazakhstan. A team of American trainers trained their Kazakh counterparts in modern theories and approaches to high need populations and was successful after tailoring their methods and approach to the local environment and cultural norms (Thorning et. al 2012). This comparison is relevant to a K-12 STEM program because it considers intercultural components, local customs and knowledge to create a flexible and coherent approach based the various needs of geographically and culturally diverse populations.

In a successful train the trainer model for program implementation, the ability of the master trainer to deliver content in an effective way is an important factor. Specifically, the top attributes cited for effective trainers are; providing feedback, communication skills, knowledge of content and the ability to use teaching aids and technology (Olson 1994). Other factors for effective trainers are listening (Stolovich 1999), problem solving (Bernstein et al 1957) and the ability to form a relationship with the students (Jacobs 1987).

Although literature on the effectiveness of the TTT model is limited in scope there are successful, documented cases throughout the country. Additional research is needed across the

board, particularly in applying a TTT model to K-12 and higher Ed. programming, but under the right conditions it appears to be an effective tool.

Action Evaluation Model; What is it and How Can It Be Effective?

To properly and effectively evaluate teacher satisfaction, a relevant and useable tool needs to be used. The Action Evaluation (AE) model appears to be useful for the purposes establishing an evaluation design for the PLTW program. It is a replicable model that utilizes modern technology creating a STEM teacher cohort that believes in the collaborative approach to STEM education, it is only natural that the method used to evaluate STEM education programs embraces the same concepts and values.

As described by Ross (2001), the theoretical basis for creating the action evaluation approach is the participation hypothesis. He cites Verba (1961), among others, to establish a widely-accepted belief that active participation in the development of a set of goals will directly lead to a higher level of commitment. The process of developing a shared set of goals and then reflecting on them as a group builds additional commitment as the individual participants feel they are positively contributing to the desired outcomes of the group. Ross also cites foundational support for AE in the Hawthorn Effect, which states that involving participants at all levels of an organization builds support for the program (p. 5). To show what an actual action evaluation looks like we can turn to *The Aria Group*, a conflict resolution consulting firm out of Yellow Springs, OH. This firm describes action evaluation as a participatory way to analyze a problem or program utilizing a multi-phase approach (Aria Group Action Evaluation, 2016).

Dr. Jay Rothman has written extensively about action research, action evaluation and its application to conflict resolution. Dr. Rothman (Aria Group Action Evaluation, n.d.) is the President and founder of *The Aria Group* and lists the three basic phases of the AE model on the company website (Aria Group Action Evaluation, n.d.):

1. Baseline: Establishing shared definitions of success and goals
2. Formative: Implementation and monitoring of actions
3. Summative: Evaluation of success.

The three phases of an action evaluation are intended to be flexible and applicable to a wide variety of organizations and situations. The fundamental structure and goals are the same, however, and creating buy-in from all participants by involving them in all phases of the design and evaluation of a given project or problem is crucial. The key feature of an AE is gaining buy-in through the practice of goal articulation at each stage of the evaluation and a constant analysis of how these goals and aims develop and change over the course of the given project, program or conflict. This feedback loop is what drives the evaluation and is what allows for participation from all levels of an organization at each stage of the process.

Bing et. al (1998) lays out some lessons learned through their experience as consultants in the field of conflict resolution. From their experience, establishing buy-in from all stakeholders should be priority number one and assessing the level of participant buy-in at the onset of the evaluation is necessary to ensure this is happening. According to the authors, there are several main reasons that participant buy-in does not develop including a lack of understanding of the methodology and lack of faith that it will be beneficial (p. 2). The best way to avoid these

problems is to enter into the project in its early stages and be prepared to fully articulate the ways in which the evaluator will benefit the group and its mission. Bing et al. (1998) also describe the value of developing deep and meaningful relationships with the convening group. Because the action evaluator is actively participating in the process, they must develop trust and standing within the group to be successful (p. 3-5). The authors conclude by discussing the need for developing 'reflexive thinking skills' among the participants. In short, this process encourages the individuals involved to explore the relationship between one's beliefs, experiences and the actions we take. By being able to empathize with each-others perspective, beliefs and values the group can better anticipate disagreements and solutions as the process evolves (p. 5-9).

In addition, the role of the evaluator is something to watch. Since the evaluator is effectively part of the group, it is necessary to avoid any of the bureaucratic entanglements that may hamper the other participants involved. Bing et al. (1998) also discuss the need to maintain the role of consultant on the project and viewed an asset and positive influence by the group. This is done through successfully facilitating dialogue and managing the progress of the evaluation when necessary. Striking the right balance of insider vs. outsider is one of the most challenging but important skill an action evaluator can develop (p. 3-9).

There are certainly areas of improvement necessary in the field of action evaluation and action research. The research on this subject did not mention donors or the issues a funding agency, group or individual may find important. This may prove to be an impediment to success depending on the funding source of a given project or program and should be something to consider.

DESCRIPTION OF PROJECT LEAD THE WAY

General Description

The purpose of Project Lead The Way is to prepare students for the global economy through problem-based hands-on science, technology, engineering and math (STEM) programs. This is accomplished through partnering with local schools, non-profit organizations and Institutions of Higher Education. As such, properly trained teachers are vital to fulfilling this goal, and the Core Training Institute (CTI) is the model used to spread the program to additional schools. The CTI provides teachers with confidence in the technical aspects of the curriculum while providing a students' understanding of expectations and mastery. The CTI is designed to give teachers the skill set necessary to successfully engage with their students through a hands-on curriculum, and deliver students that are competent in the STEM fields and prepared for the challenges that today's economic realities present. This is accomplished through effectively completing the curriculum of the course in a one or two-week time-period. Teachers physically produce all project work required of students and must collaborate with their colleagues in teams, the same way their students will need to do in their classrooms (PLTW, Our Programs and Curriculum 2016).

Project Lead The Way Staff and Leadership Structure

Project Lead The Way has a structure that includes a Board of Directors and full time staff based out of its national headquarters in Indianapolis, IN. Project Lead The Way also employs multiple representatives to represent the organization in various territories throughout the United States

and partner with affiliate Universities to collaborate at the state level. The Board of Directors is comprised of current and former executives from large multi-national corporations including Lockheed Martin, DOW Chemical and General Motors as well as representatives from non-profits and a government (PLTW Board of Directors, n.d.).

The current President and CEO, Vince Bertram, Ed. D., has led PLTW since joining the organization in 2011 and leads a 9-person senior leadership team. Senior Vice President and Chief Talent Officer Jonathan Dilley serves as an advisor on legislative issues and focuses on aspects of PLTW team member development, recruitment and retention. Senior Vice President and Chief Strategy Officer Maureen Weber provides leadership for the day-to-day operations of the organization and manages various initiatives put forth by the organization. Senior Vice President and Chief Communications Officer Dorothy Gorman leads the PLTW marketing and communications team to grow brand awareness, manage key events and facilitate networking opportunities for the program's participants. Senior Vice President and Chief Partnerships Officer Rex Bolinger, Ed. D. takes the lead on development and partnership opportunities for PLTW. John Visconti, Senior Vice President and Chief Financial Officer, leads the finance, accounting, human resources and supply chain management for Project Lead The Way. Senior Vice President and Chief Technology Officer Valerie Osinksi is responsible for developing and maintaining the technological systems used by PLTW to fulfill its primary mission. David Dimmett, Senior Vice President and Chief Engagement Officer leads the organizations network of regional Vice Presidents, directors of school engagement and the PLTW solution center. Tom Luna, Senior Vice President and Chief Governmental Relations Officer heads the Government

Relations team which works to advance PLTW's policy at all levels of government (PLTW Board of Directors, n.d).

At the local level, PLTW partners with affiliate Universities including the University of Minnesota, Twin Cities Campus. The author can attest from experience that affiliate Universities are charged with advocating and promoting the program. Affiliate Universities also act as host for CTI's on campus each year. The College of Science & Engineering (CSE) is the partner College at the University of Minnesota. Associate Dean Paul Strykowski and Assistant Dean Susan Kubitschek are the administrators responsible for maintaining the relationship between CSE and PLTW. Joseph Nieszner is the main program coordinator responsible for the day to day management of the programs offered. This includes managing logistics for, planning and running the CTI training programs held on the University of Minnesota campus.

Curriculum

The PLTW Curriculum is broken into 5 separate programs intended to engage students as young as Kindergarten, all the way through 12th grade. Each program contains multiple units, tailored to the target student population and intended to challenge students through an activity, project and problem-based design meant to be relatable to the world outside of the classroom. The APB approach is a collaborative way to teach the STEM concepts and skills necessary for success and provides an opportunity for creativity by challenging students with open ended problems to solve. This approach is modeled in the figure 1 below, (PLTW, Our Programs and Curriculum).

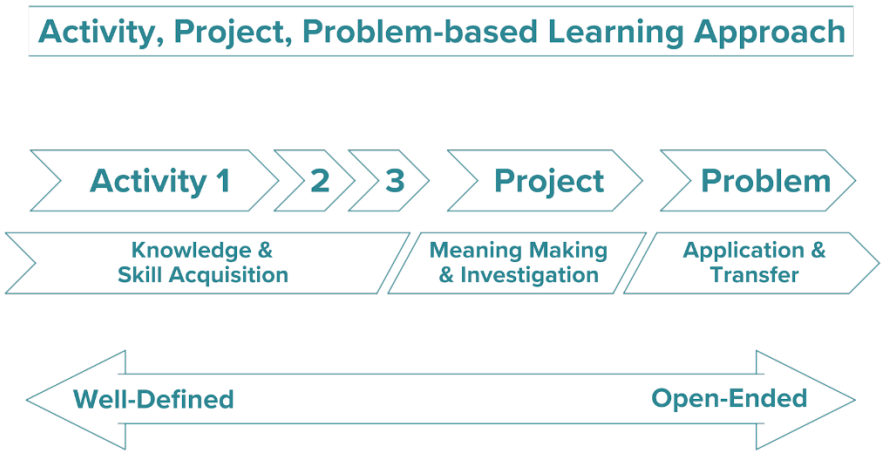

Figure 1. The activity, project, problem-based learning approach is the basis for all PLTW curriculum and training models. Adapted from *PLTW, Our Programs and Curriculum (2016).* Retrieved from https://www.pltw.org/our-programs/curriculum

Below is a brief description of each program and a listing of each curriculum unit:

1. PLTW Launch

PLTW Launch is intended for K-5 students and engages them with a hands-on, activity based approach. PLTW Launch contains 24 separate modules that align with the Next Generation Science Standards, Common Core State Standards for Math and English Language Arts (PLTW Launch Curriculum). Each module contains approximately 10 hours of content and can be taught one at a time or in tandem. Launch programs are designed to be taught at a pace and tempo that best aligns with the individual needs of each school.

The Launch Modules for each grade level are detailed on the PLTW website and will be briefly detailed to provide context.

Kindergarten - Structure & Function: Exploring Design, Pushes and Pulls, Structure and Function: Human Body, Animals and Algorithms (PLTW Programs, n.d.).

First Grade - Light and Sound, Light: Observing the Sun, Moon, and Stars, Animal Adaptions, Animated Storytelling (PLTW Programs, n.d.).

Second Grade - Material Science: Form and Function, Material Science: Properties of Matter, The Changing Earth, Grids and Games (PLTW Programs, n.d.).

Third Grade - Stability and Motion: Science of Flight, Stability and Motion: Forces and Interactions, Variation of Traits, Programming Patterns (PLTW Programs, n.d.).

Fourth Grade - Energy: Collisions, Energy: Conversion, Input/Output: Computer Systems,Input/Output: Human Brain (PLTW Programs, n.d.).

Fifth Grade - Robotics and Automation, Robotics and Automation: Challenge, Infection: Detection, Infection: Modeling and Simulation (PLTW Programs, n.d.).

2. PLTW Gateway

The PLTW Gateway curriculum is for middle school students and aims to encourage exploration, critical thinking and problem solving. These 10 modules are intended to both engage students through a hands-on approach to the STEM concepts and methods and encourage them to pursue these concepts and subjects further when they reach high school.

Gateway modules are taught over the course of a semester, topics are; Design and Modeling, Automation and Robotics, App Creators, Computer Science for Innovators and makers, Energy and the Environment, Flight and Space, Science of Technology, Magic of Electrons, Green Architecture, Medical Detectives (PLTW Programs, n.d.)..

3. PLTW Computer Science

Aimed at students in grades 9-12 the Computer Science modules seek to empower them to become creators of the technology that pervades everyday life, not just consumers. This program uses an interdisciplinary approach to get teach computational thinking combined with the coding skills that will be in demand for any academic or professional career path. The Computer Science Modules are taught in one semester and include these following topics; Computer Science Essentials, Computer Science Principles, **c**omputer Science A, Cyber Security (PLTW Programs, n.d.).

4. PLTW Engineering

The Engineering program is for High School students in grades 9-12. These courses utilize an interdisciplinary activity to engage students with a real-world problem to solve. This program aims to teach engineering knowledge and skills while developing creativity and problem solving abilities.

These units are designed to be taught over one semester, the modules are; Introduction to Engineering Design, Principles of Engineering, Aerospace Engineering, Civil Engineering and Architecture, Computer Integrated Manufacturing, Computer Science Principles, Digital

Electronics, Environmental Sustainability, Engineering Design and Development (PLTW Programs, n.d.).

5. PLTW Biomedical Science

This program introduces 9-12th grade students to the medical sciences by simulating a real-world scenario and applying techniques and equipment used in the profession. These units force students to apply their knowledge to solve a problem faced by the class while learning how to obtain and apply information and knowledge. These units are; Principles of Biomedical Science, Human Body Systems, Medical Interventions, Biomedical Innovation (PLTW Programs, n.d.).

TRAINING

Participants

Participation in a PLTW training program is open to any eligible K-12 teacher choosing to pursue certification as a PLTW classroom teacher. To be considered eligible one must be employed by a US based school that has committed to adopting a PLTW program. Project Lead The Way seeks dynamic and passionate educators dedicated to STEM education and welcome any interested instructor whose home institution has agreed to their inclusion. There are no pre-requisite requirements to becoming a certified PLTW classroom teacher beyond the support of the home school or district (PLTW Professional Development, 2017).

To become a certified PLTW teacher a participant must complete two separate but sequential training programs, Readiness Training and Core Training. Readiness training is an online module

based instructional program and Core Training is an intensive in person training program meant to mimic the rigor and expectations placed on students in a PLTW classroom. Core Training is facilitated by experienced PLTW teachers who have undergone additional training to become Master Teachers.

Participants come from all 50 states and typically attend a Core Training session located geographically close to their home. Since cost can be a factor for many school districts, PLTW encourages participants to select Core Training sites that require little to no travel. If the training schedule does not allow for this, or there simply are no training sites located near the participant, they may travel to any location they choose.

Master Teachers

Each Core Training session is administered by two experienced PLTW classroom teachers who have undertaken additional training to be qualified to facilitate these courses. Master Teachers, as they are called, impart their knowledge of the program they specialize in through a classic train-the –trainer model. The selection process to become a Master Teacher is controlled by the National PLTW organization and is tightly controlled and regulated to ensure consistent and quality instruction throughout the program. To qualify, a classroom teacher must apply for the position through the PLTW professional development program, complete the necessary training and then undergo an apprenticeship period before they entrusted with a training cohort.

According to a recent webinar titled *Curriculum and Professional Development Affiliate Webinar* (2017) hosted by PLTW for training site coordinators, the 2017 cycle will include 530 active Master Teachers who are eligible to lead training sessions. Most of these individuals will

facilitate multiple sessions over the 10-week period when the vast majority CTI programs take place and are compensated for their efforts. The compensation is determined at the national level and includes $2000 per week, plus housing, meal and travel expenses. These funds are paid directly to the Master Teachers by the host institution and typically coordinated between the two parties directly, with little to no involvement from the national organization.

Master Teachers are assigned to a specific training site and date by the national organization, however, each training site may submit a request for specific Master Teachers. These assignments are made based on the host site requests, the availability of each Master Teacher and the ratio of seasoned leaders to apprentice level facilitators. There do not appear to be any cultural or language considerations made beyond the commitment to make placements that reduce travel expenses as much as possible.

Cost of Participation

The cost to participate in a PLTW Core Training Institute session is determined by several factors.

1. Tuition based on the course. Tuition for a 1-week session is currently $1100, a 2-week session is currently $2200.
2. Travel expenses incurred by the participant to physically get to the host site. This cost can vary dramatically depending on the mode of transportation required and is typically covered by the participant's home school or district.

3. Other costs associated with the program including housing, parking and meals. It is recommended that host sites adhere to commonly accepted per-diem rates for their areas and do everything possible to keep fees as affordable as possible.

Table 1. details a recent example of the costs associated with one person attending a 2014, 1-week CTI held on the University of Minnesota, Twin Cities campus.

Table 1.

2014 CTI per person cost breakdown for the University of Minnesota, Twin Cities campus.

Item	Cost
Tuition	$1100
Parking, Wi-Fi, Meals	$427
Housing	$253
Total Expenses	$1780

Note. The information in Table 1 is based on historical data from the author's files.

All billing and payments are coordinated directly between the PLTW host institution and the participants sponsoring school or district. The national PLTW organization does not facilitate the financial component of its training institutes beyond setting tuition rates and affording the host institutions power to delay certifying completion of the program if payment is not received in a timely manner.

These costs are almost exclusively paid for by an individual's home school or district. For example, a review of all past participants who have participated in a CTI on the University of Minnesota, Twin Cities campus shows that 100% of attendee's costs were paid by a K-12 school

or district. This is not a policy, however, the costs in time and money are likely too high for any individual to take on without institutional support.

Readiness Training

Registration is accomplished online through the Project Lead The Way website. To be eligible for a Core Training Institute session a participant must create an account and complete a series of online, web based courses and assignments for the specific program they are pursuing. The intent is to provide base knowledge and an overview of course content to ensure participants are committed, able to handle the curriculum and have obtained all necessary software prior to arriving at a host site. According to PLTW:

> Readiness Training is a set of courses that introduces teachers to the PLTW experience and provides content and software resources that teachers need in order to be successful at Core Training. Teachers complete the self-paced Readiness Training coursework online before attending course-specific Core Training. Each Readiness Training course will require between two and four hours to complete (PLTW Professional Development 2017).

An example of a Readiness training sequence for Design and Modeling that is currently open for registration is detailed in table 2.

Table 2

Project Lead The Way Readiness Training Sequence

Element	Description	Time
The Project Lead The Way Experience	This section will introduce you to Project Lead The Way as an organization, its focus and mission, an overview of its pathways, and an outline of PLTW's three phase professional development model.	2-4 hours
Getting Started With Design and Modeling	This Readiness course will introduce you to PLTW Design and Modeling (DM). It contains introductory information and some content readiness assignments that will help prepare you for PLTW Core Training. This course is required for all DM Readiness and Core Training participants	2-4 hours
Getting Started With Autodesk 123D© Design	This readiness course will guide you through the installation of relevant software. It contains tutorials and introductory assignments that will help prepare you for Core Training. Successful completion of this readiness course is required to register for a Core Training event.	4-8 Hours
Getting Started With Geogebra	This readiness course will guide you through the installation of relevant software. It contains tutorials and introductory assignments that will help prepare you for Core Training. Successful completion of this readiness course is required to register for a Core Training event.	4-8 Hours

Note. Table 2 lists one specific Readiness Training sequence. Each Project Lead The Way module will require the completion of a separate and distinct sequence. Information adapted from https://www.pltw.org/our-programs/professional-development

This training sequence must be fully and successfully completed before an individual can participate in an onsite training program (PLTW Professional Development, 2017).

Host Sites

PLTW Core Training Institutes are conducted in all 50 states on the campuses of partner institutions of higher education. A network of colleges and universities provide resources, expertise, leadership and guidance to the K-12 schools and administrators in their respective states. They also contribute to these CTI programs by providing the physical spaces needed as well as the logistical support necessary to operate a one to two-week residential training program. The state of Minnesota, for example, has three Affiliate Universities who collaborate and share the burden to provide dozens of opportunities per year. The University of Minnesota-TC, St. Cloud State University and Minnesota State University-Mankato will be hosting a total of 21 CTI sessions during the summer 2017 season.

Implementation

PLTW offers guidance and details multiple strategies for implementing its programs. This information is published in the form of a PDF document, available for download online through the PLTW website. The PLTW Implementation Guide is meant as an easy to follow tool, applicable to any school or district in the country. The intention of this process is to provide firm and useful guidance while simultaneously allowing for the maximum amount of flexibility and innovation at the local level to establish and grow sustainable and high quality PLTW programming.

This guide uses a 5 step approach to implement and integrate PLTW into a school using the same basic process regardless of program type and age group. According to this document, the implementation process is intended to support student development through its curriculum and professional development for teachers throughout this process.

Step 1: Choose the Best PLTW Program(s) for Your District

The first step to implementation is choosing the appropriate program for the school or district. It is recommended that PLTW be introduced for the first time in the younger age groups. The hope is that by the time students reach high school, they are familiar with the curriculum and approach.

Step 2: Select Your Program Implementation Approach

The PLTW Implementation Guide offers unique guidance to each of the 51 separate modules available through the 5 program categories. The individual implementation approach offers an overview of how the program was designed, the implementation options available and things to consider ensuring student readiness. The approach taken is entirely up to the school and/or district, offering both flexibility and the ability to consider local issues, factors, and subject matter into the curriculum.

Step 3: Build Your Foundation

After developing an implementation plan, schools can register through the PLTW website to officially begin the process. If a school is the first in its district to adopt PLTW, additional steps are required to ensure cooperation and collaboration with the administrators and officials from all relevant political and administrative bodies. When this process is complete, schools can go forward with nominating teachers to become certified and begin to order and equipment and supplies.

Step 4: Meet myPLTW

myPLTW is the official portal for engagement with the organization at all levels. This includes school and district administrators, school principals, teachers and students. Described as the "nerve center" of the PLTW program for participants, myPLTW allows access for lesson plans, curriculum, school and course rosters, professional development and online communities that enable discussion of best practices and program development.

Step 5: Build Your PLTW Community

After officially rolling out PLTW in the school, the organization strongly encourages and helps facilitate further engagement. Examples include forming partnerships with local businesses to create real world problems to solve with a direct impact on the student's community, student groups, and spreading PLTW across other classrooms in the school. PLTW offers support for these initiatives and actively encourages schools to establish and grow a strong support network for the program (PLTW Implementation Guide, n.d.).

EVALUATION RATIONALE

As stated above, the purpose of this evaluation is to analyze the effectiveness of the PLTW classroom-teacher training program. It is also the authors intention to assess participant satisfaction with the general approach to training and the methods and strategies employed.

This evaluation focuses on developing clear and measurable goals through in person interviews and small group discussions. By involving the classroom-instructors who participated in the training program we can expect to build buy-in for the evaluation and a sense of ownership

among the stakeholders. As the evaluation evolves and moves through the stages of design to implementation, data will be collected and fed back to the stakeholder group for further discussion and evaluation. The ongoing process of evaluation, discovery and discussion is the most important component of this initiative. These discussions will be facilitated and guided by the evaluator, but the outputs and actionable decisions will be established by the stakeholder group.

Surveys are another vital component of this evaluation design. While the process of establishing goals as a group is important, so are the opinions of the individual stakeholders. This is an important process and allows the evaluator to identify trends and areas of disagreement. In addition to the PLTW trained classroom-instructors the evaluation will survey school staff, teachers and administrators to assess their view of the outcomes related to the PLTW training program. In addition, parents and students will also be surveyed to gauge their level of engagement and satisfaction with the implementation of Project Lead The Way. Given the likelihood for multiple surveys that contain a large amount of data, Likert scales should be used as the question design model to produce easy to interpret data. A few open answer questions should also be used, especially when formulating goals. Open ended questions enable individuals to offer feedback, opinions, and suggestions in confidence. Surveys are an inexpensive tool that can serve as a benchmark and can identify relevant trends that can then be discussed in a group setting.

Interviews with the individual stakeholders and relevant school personal will be utilized as well, primarily at the beginning and conclusion of the evaluation. Establishing a personal one-on-one

relationship early will boost the evaluator's chances for success and serve as an ice breaker when it comes to the group discussions. In addition to establishing a clear administrative and power structure of the school involved, these interviews can be used to leverage differences and disagreements between groups to foster discussion and conflict resolution through non-confrontational methods. By voicing concerns or opinions to the evaluator, they can be introduced to the group by the facilitator without putting any individual in an awkward position. In this way, the evaluator can act as a go between to help lead discussions on topics and issues that may be contentious in an impersonal and professional manner.

Small group discussions will be facilitated by the evaluator to identify the values and opinions of the stakeholder group. Using small group discussions will allow members to share concerns, anecdotes and ideas without the fear of reprisal and will allow its members to work through their ideas and concerns. As the evaluation design and implementation process evolves, the evaluator can feed updated data and information to the group for discussion, analysis and action. This should build buy-in from the entire organization and allow its members to take ownership of the process and its outputs.

While the qualitative data gathered from stakeholder surveys, discussions and interviews helps to determine the level of buy-in and satisfaction with the evaluation process, the quantitative data collected helps to determine if our efforts are having any measurable impact. The Likert scale data can help us determine if the current process is working to improve buy-in and establish participant sentiment at different points in the process.

EVALUATION DESIGN

The purpose of this evaluation is to assess the effectiveness of the classroom-teacher training program currently provided by Project Lead The Way (PLTW). A review of the literature shows how the train-the-trainer model can be a productive and cost effective tool; however, deficits in key areas of the process may produce negative and unwanted outcomes. By utilizing this method, PLTW is relying on both the effectiveness of its Master Teachers to deliver course content and the ability of classroom-instructors to comprehend and deliver the curriculum.

If facilitated improperly, this teacher training program could be an obstacle for program participants attempting to implement the activity, project and problem-based (APB) approach to the PLTW curriculum. The author proposes an action evaluation to investigate the PLTW Core Training Institute and Readiness Training programs to determine if this approach imparts the knowledge and skills necessary to implement the PLTW curriculum utilizing the APB method. Another purpose of this evaluation is to assess classroom-instructor satisfaction with key elements of the training process including the venue, delivery format, and training methods and materials. The evaluation will also analyze classroom teacher confidence to implement the APB approach following the training program and measure classroom-teacher opinions of the training methods and strategies employed by PLTW.

This action evaluation is designed to both stand alone and easily nest within a larger action research evaluation to assess the overall impact of Project Lead The Way within a school. If a larger evaluation is implemented, a comprehensive action research approach can be expected to

produce a feedback loop with relevant stakeholder groups, creating a self-sustaining assessment and analysis of the program. Figure 2. Shows how the process functions and where this evaluation, represented by the "analyze instructor readiness and satisfaction" component, would fit.

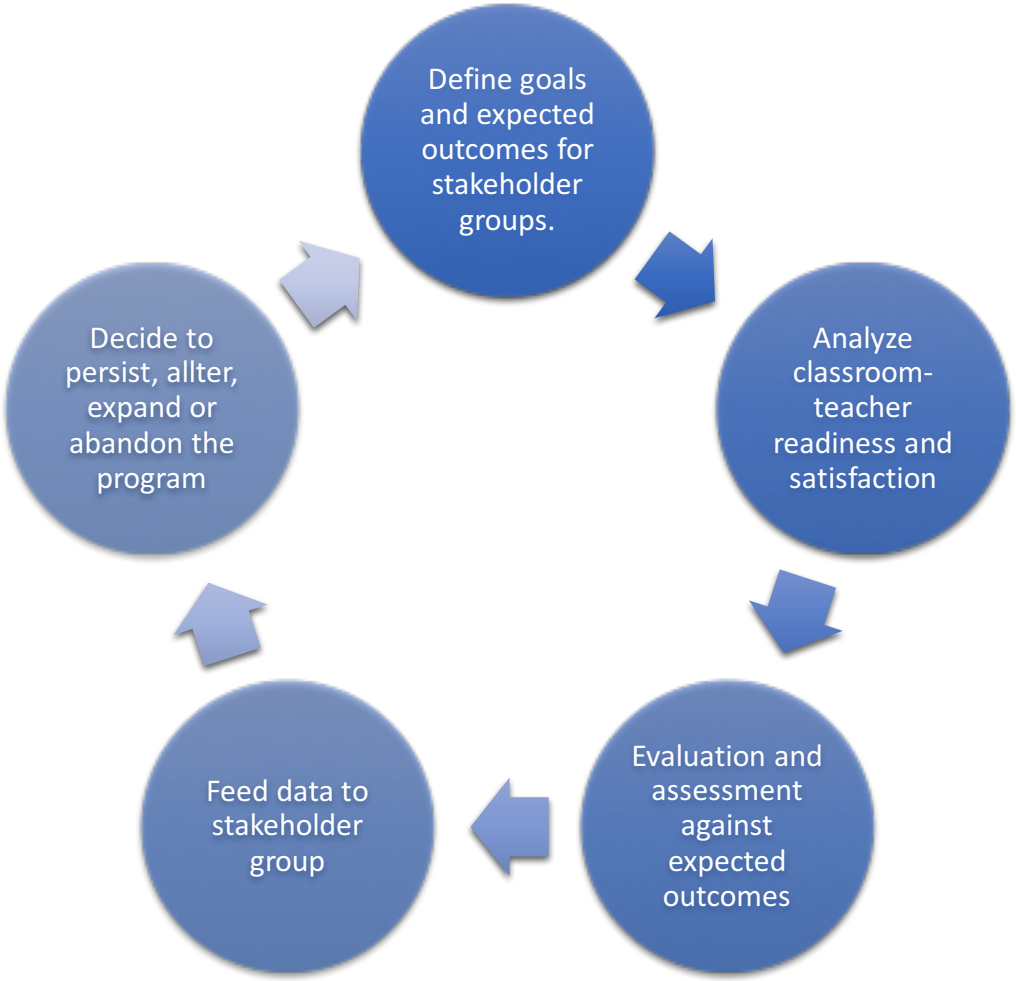

Figure 2. This model shows how this evaluation of teacher readiness and satisfaction with the training program might fit into a larger evaluation of PLTW.

The following questions are used to construct the evaluation design and guide the process. As stated above, it is the author's intent to assess the PLTW training model's impact on classroom-instructor readiness and confidence to implement the APB approach and deliver the curriculum. The evaluation design is also intended to assess classroom-teacher satisfaction with the PLTW training model. For the purposes of this evaluation design, the stakeholder group is defined as the PLTW classroom-instructor, or instructors, in the target school who have successfully completed PLTW training and are implementing PLTW methods in their classrooms.

1. Who are the PLTW classroom-teachers?

   Information Needed: A clear understanding of the school structure is required. In addition, the larger context in which the school operates must be made clear. The evaluator will need to identify all PLTW certified classroom instructors in the target school.
   Source of Information: This information will be obtained through multiple sources including school websites, interviews with the appropriate school personnel and the PLTW data base.
   Method: Use of public records and published resources. In-person and electronic communication with the PLTW classroom-instructor(s). Project Lead The Way data base of certified classroom-instructors.

2. What are the expected outcomes stemming from classroom-instructor participation in the PLTW training program?

   Information Needed: What is the expected classroom-instructor proficiency level after completing the training program? What are the expectations of the subject school administrators? What are the expected outcomes of the classroom-instructors following training? What are PLTW's expected outcomes from the training program?

   Source of Information: PLTW classroom-instructors, school administrators, PLTW personnel involved in the implementation and design of the training program. PLTW training and curriculum documentation and materials.

Method: In person interviews and electronic survey with PLTW classroom-instructors. Interviews with administrators. Interviews with PLTW personnel and Master Teachers. Analysis of the available and relevant PLTW documentation and training materials.

3. Following the training process, what is the level of PLTW classroom instructor confidence to deliver the PLTW curriculum?

   Information Needed: Qualitative data detailing the attitude and confidence level of each individual instructor to implement the PLTW approach and curriculum in their classrooms.

   Source of Information: PLTW classroom-instructors in the target school. PLTW instructor grades and scores from the PLTW training module.

   Method: Interviews, electronic survey, group discussions with the PLTW classroom-instructor. Comparative analysis of instructor confidence with their performance in specific components of the training program.

4. What is PLTW classroom-teacher satisfaction with the PLTW training program?

   Information Needed: Qualitative data on classroom-instructor satisfaction with specific components of the training program to include venue, training methods and curriculum employed. Documents detailing the program and its component parts.

   Source of Information: PLTW classroom-instructors. PLTW training materials. PLTW personnel involved with the program.

   Method: In person interviews, group discussions and electronic surveys with PLTW the classroom-instructors. Analysis of accessible and applicable PLTW training materials.

5. What is stakeholder satisfaction with the Master Teachers who delivered the training?

   Information Needed: The Master Teacher's need to be identified. Qualitative data to analyze stakeholder opinion of the Master Teachers who facilitated their training program. Quantitative survey data from past Core Training Institute's facilitated by the Master Teachers in question.

Source of Information: PLTW classroom-instructors, PLTW databases, Master Teachers involved.

Method: In person interviews, electronic surveys, group discussions with the PLTW instructors. Analysis of all available survey data obtained from PLTW. Interviews with the Master Teachers.

6. In what ways are PLTW classroom-teachers implementing PLTW strategies?

   Information Needed: Data on the current classroom content and curriculum. Qualitative and testimonial data on the current state of the implantation process. Documentation detailing the PLTW process.

   Source of Information: Course materials including syllabi, lesson plans and related documentation. The PLTW classroom-teachers. School administrators involved with the PLTW course.

   Method: In person interviews with the PLTW classroom-instructors and relevant school administrators. Analysis of lesson plans, syllabi and other course documentation. Electronic surveys of PLTW classroom-instructors and relevant school personnel. Comparative analysis of PLTW documents detailing the APB approach and documentation provided by the subject school.

EVALUATION STANDARDS

This evaluation will use the Program Evaluation Standards, specifically, the Joint Committee on Standards for Educational Evaluation. The four main points contained in the PES are feasibility, propriety, accuracy and utility. This standard is excellent for the evaluation of educational programs which is the main-focus of this study.

Feasibility: This project is based on proven and effective evaluation practices that that will have a minimal disruptive impact on the individuals and institutions involved. By involving those

most likely to experience disruption in the planning and implementation process, any issues can be resolved in a timely manner or avoided entirely. It is the author's intent to keep costs as low as possible and the methods, strategies and project management structure have been designed with cost mitigation in mind.

Propriety: This evaluation will address the needs of all stakeholders and considers the many variables that could impact program development. This study is intentionally designed to consider local factors and should not affect the evaluator's ability to conduct a successful action evaluation. The methods used are inclusive and will allow a diverse range of opinions and information to be considered. Both qualitative and quantitative methods will be used to gather data, providing a balanced approach to the evaluation study.

Accuracy: The context of this program has been identified. Data sources are either first hand responses provided by staff, teachers, administrators and students or hard data sets provided by reputable institutions. The evaluation will be conducted in a transparent way with timely and regular communication with the stakeholder group(s). Appropriate cultural considerations will be taken to ensure all responses and decisions accurately reflect the populations involved and protect those whose input could lead to negative or unintended consequences.

Utility: All stakeholders and the object have been accurately identified. The purpose of the evaluation is clearly defined and in line with the goals and rational of the program and what the current literature identifies as best practices for K-12 STEM education. Communication will be

responsive and regular, this is especially important as the information loop is established and sustained.

LIMITATIONS OF THE EVALUATION

There are several challenges the author can envision when attempting to use an action evaluation in this way. These challenges focus on the staff time spent away from the classroom and the financial needs to run the evaluation. This may be problematic considering the cost already associated with implementing PLTW in a school. Other challenges involve the role of the evaluator and the potential pitfalls that could render an action evaluation of this nature ineffective.

The first challenge relates to collecting relevant data necessary to completing an effective evaluation. Evaluating the effectiveness of the classroom-teacher training program, as well as teacher satisfaction with the training process, will require collecting relevant and useful data and analyzing it to draw meaningful conclusions. Detecting patterns in survey responses, group discussions and interviews will require a representative sample size and must include all regional, socioeconomic and cultural factors. Analyzing the large amounts of data necessary to ascertain a legitimate conclusion will require many hours of labor, collaboration with trained statisticians and a significant financial commitment.

The second challenge of this study is deciding who to include in the evaluation as a data source. It is logical to include teachers, administrators and staff that work directly with the PLTW

teachers implementing the program. What may not be clear is to what extent parents, district level administrators and even political positions such as school board members should be involved. It will be up to the evaluator to have discussions with the powers that be to establish a mandate to conduct this process without interference, or, to include any office or person who has the power to "pull the plug" directly in the process.

The third challenge relates to the evaluators skills and ability to successfully lead the evaluation process. This person should be able to act as facilitator and conduit for information and data without influencing the decisions made by the group. At the same time, the evaluator will have to extract a clear and actionable set of goals from the participant group to proceed with the evaluation and establish a feedback loop. Darling (1998) details several other specific ways an action evaluation can be subverted including a lack of clear goals. If this crucial step of the process produces muddled or confused goals the evaluation is doomed from the beginning. This could result from an inability to establish a proper rapport with the participant group. In addition, it will be vital to avoid an over reliance on technology and maintain a direct person to person connection with the stakeholders. This is especially important if the evaluator is not local. Through the reflection and analysis process the participants should not be restrained by a reliance on electronic feedback collection methods, surveys should be used as a tool for the larger discussions only.

Additionally, most schools that can be the subject of this study will be public schools. As such, funds will be limited and other political factors may not be under the control of the evaluator. Because time will be spent outside of the classroom, there may be issues with unions that will

not permit their members to participate without additional compensation and administrators who will not be willing to negotiate this point. There may also be competing political priorities within the larger political and cultural context in which the school exists. Even if the evaluator can navigate the political environment successfully, the political situation could change after an election. These factors will have to be taken into consideration when deciding which school this evaluation should be attempted.

The theoretical foundation for this evaluation design assumes that the literature is correct in declaring that a new approach to STEM education is necessary. It should be a priority to ascertain the opinion of the students themselves before, during and after the evaluation process to determine if they feel the same way. A further review might include both the opinions and experiences of students and their parents who have experienced both the traditional STEM education approach and the new approach that is promoted by Project Lead The Way. In addition, without the ability to engage other schools and districts who have had a similar experience we cannot be sure any conclusions and outputs are unique. As with any legitimate evaluation, a large and diverse data set will need to be developed over time to compare the impact of the PLTW training program and participant satisfaction.

Finally, the evaluation does not consider classroom-instructors within the school who are not able or do not wish to implement a PLTW program. Currently, PLTW courses are an elective within a broader science and math curriculum and may be depleting resources from other areas of the school which may have unintended negative consequences. While the PLTW philosophy

and project can be a useful and productive program, not all classroom-instructors will have the skill set or ability to succeed.

CONCLUSION

The need for workers trained and educated in STEM fields is likely to increase in the foreseeable future. As such, it is crucial to ensure that all K-12 students in America's school system are given the opportunity to succeed in this sector. To empower the largest number of children with the technical competency and engage them in creative and interesting ways will require education reform. The approach proposed in this paper is feasible under the right conditions and if implemented correctly, can result in improvements to Project Lead The Way's dynamic and modern approach to STEM education. It is almost certainly true that the opportunity to try this approach will not present itself without the leadership of a superintendent and school administrative and teaching staff who have the vision and ability to try something new. To offer the most impactful feedback, the action evaluation approach should be attempted in a middle school setting and gradually expanded to include the high school level. This will afford the opportunity to document the impact of a new age approach to STEM education and share its successes and failures with educators throughout the country.

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